Chapter 8

THE FRAMEWORK: STANDARDS 6-12

(The Process Standards)

Standard 6: Organisms
Standard 7: The Diversity of Life
Standard 8: Structure and Behavior of Matter
Standard 9: Matter, Forces, and Energy Transformations
Standard 10: Earth Systems
Standard 11: The Universe
Standard 12: The Environment

SCIENCE STANDARD 6

All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

INTRODUCTION

This standard serves as a scaffolding on which students build their biological understanding of life. The interdependence of living things is a major focus. To achieve this standard, students determine the characteristics that are unique to life. These common processes are displayed in the wide variety of life on Earth. Although tremendous variation exists among living things, students should understand that individual organisms are part of a larger system. As part of this system, living things depend on each other.

Within individual living things, structure is related to function. This relationship is even displayed on the cellular level. Students should understand that multicellular organisms are composed of interacting components such as tissues and organs.

This standard emphasizes the flow of energy as a common theme that is encountered at the level of cells, organisms, and ecosystems. A cell's energy producing and consuming activities are controlled by specific molecules. The reciprocal relationship between photosynthesis and respiration establishes the interdependence of the life cycles interacting within an ecosystem.

DEVELOPMENTAL OVERVIEW

In grades K-2, children begin to recognize the uniqueness of life by investigating the characteristics of living and nonliving things. In grades 3-4, activities challenge students' misconceptions about the characteristics of life. They realize that some nonliving things can act as though they are alive! In the intermediate grades, students not only determine the differences between living and nonliving things (grades 5-6), but also begin to describe the major categories of plants and animals (grades 7-8). At the high school level (grades 9-12), students use the presence of cells and DNA as indicators of life.

The relationship between structure and function is introduced in primary grades (K-4) through the use of concrete examples. This concept is expanded to increasingly abstract levels until high school, where students are challenged by structure and function at the molecular level.

The investigation of interdependence, the flow of energy, and life cycles begins in grades K-2 with observations. In grades 3-4, children recognize the existence of a food chain, and they participate in activities that describe the roles of different organisms in a food chain. In grades 5 or 6, students begin to explore ecosystems. More sophisticated studies of interdependence begin in grades 7 or 8

by evaluating the influence of the nonliving environment on an ecosystem. At the high school level, students investigate the energy interdependence of living things at the biochemical level. The relationship between photosynthesis and respiration is established in terms of energy conversion.

DESCRIPTIVE STATEMENT

The study of science must include the diversity, complexity, and interdependence of life on Earth. Students should know how organisms evolve, reproduce, and adapt to their environments. Standard 6 (originally called "5.6") and Standard 7 ("5.7") serve to define the fundamental understandings of the life sciences.

CUMULATIVE PROGRESS INDICATORS

By the end of Grade 4, students

1. Compare and contrast living and nonliving things.
2. Determine the basic needs of organisms.
3. Show that living things have different levels of organization.
4. Show that plants and animals are composed of different parts serving different purposes and working together for the well-being of the organism.
5. Describe life cycles of organisms.
6. Group organisms according to the functions they serve in a food chain.
7. Identify the major systems of the human body and explain how their functions are interrelated.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 8, students

8. Describe and give examples of the major categories of living organisms and of the characteristics shared by organisms.
9. Recognize that complex multicellular organisms are interacting systems of cells, tissues, and organs.
10. Identify and describe the structure and function of cell parts.

11. Explain how organisms are affected by different components of an ecosystem and the flow of energy through it.

12. Illustrate and explain life cycles of organisms.

Building upon knowledge and skills gained in the preceding grades, by the end of Grade 12, students

13. Identify and describe organisms that possess characteristics of living and nonliving things.

14. Identify and explain the structure and function of molecules that control cellular activities.

15. Explain how plants convert light energy to chemical energy.

16. Describe how plants produce substances high in energy content that become the primary source of energy for animal life.

17. Compare and contrast the life cycles of living things as they interact with ecosystems.

LIST OF LEARNING ACTIVITIES FOR STANDARD 6

GRADES K-4

Indicator 1:

GRADES K-2
Is It Alive?
Check It Out!
Take a Hike!

GRADES 3-4
Are Raisins Alive?
Scavenger Hunt!
Hay Infusion

Indicator 2:

GRADES K-2
[no activities]

GRADES 3-4
Fish Watching
Critter Watching, continued
Ant Feeding
Mold Growing
Egg Hatching

Indicator 3:

GRADES K-4
Ant Farm Cooperation

GRADES K-2
Beehive Business
More Role Play

GRADES 3-4
Social Organization, continued
Animal Homes
Embryonic Development

Indicator 4:

GRADES K-2
Aquatic Adaptations
Invent the Animal!
Create a Dinosaur!

GRADES 3-4
[no activities]

Indicator 5:

GRADES K-2
Teddy Bears and Their Homes

GRADES 3-4
Composting
Growing "Fast Plants"
Critter Watching

Indicator 6:

GRADES K-2
Fly Away Home!
Outdoor Rot
Indoor Rot

Grades 3-4
Constructing Food Webs
Observing Food Chains

Indicator 7:

GRADES K-4
Fasten Seat Belts!
The Nervous System

GRADES K-2
Smelling
Hearing
Touching

GRADES 3-4
The Circulatory System
The Digestive System
The Respiratory System
The Immune System

GRADES 5-8

Indicator 8:

GRADES 5-6
Field Trip!
Tree/Leaf Identification

GRADES 7-8
Classifying
Animal and Plant Diversity
Plant and Animal Characteristics

Indicator 9:

GRADES 5-6
System Components
Multimedia Investigations

GRADES 7-8
Images of the Hierarchy
Multimedia Investigations
Biosphere Components

Indicator 10:

Grades 5-6
Leaf Model

Grades 7-8
Analogies
Time Line
Cell Model

Indicator 11:

GRADES 5-6
Ecosystem Research
Ecosystem Simulations

GRADES 7-8
Environmental Factors
Population Studies
Energy Flow

Indicator 12:

GRADES 5-6

Mealworm Life Cycle
Bird Life Cycle

GRADES 7-8

Human Life Cycle
Frog Life Cycle
Butterfly Life Cycle
Plant Life Cycles
Career Exploration

GRADES 9-12

Indicator 13:

Respiration and Growth Investigations
Pond-Water Life
Viruses and Technology
Viruses and Health

Indicator 14:

Modeling Organic Nutrients
Testing for Organic Nutrients
Testing Enzyme Activity

Indicator 15:

Investigating Photosynthesis

Indicator 16:

Illustrating Plant/Animal Interdependence
Investigating the Photosynthesis/Respiration Connection

Indicator 17:

Effect of Environmental Factors on Germinating Seeds
Fallen Leaves and Invertebrate Populations

Indicator 1: Compare and contrast living and nonliving things.

LEARNING ACTIVITIES: Grades K-2

Is It Alive? Students compare a live fish with a picture of a fish. Are they both fish? How are they the same? How are they different? Students identify what it is that makes the fish alive. If their response is "motion," a wind-up toy might challenge their thinking. If their response is "reacts to touch," a toy that changes direction when it makes contact can cause them to rethink their answer. Encourage students to wonder out loud.

Check It Out! Students can help set up aquariums or terrariums, in which they raise many different kinds of plants and animals. They can record their observations in picture logs and journals. Over time, students will start to form ideas and conceptions about living versus nonliving.

Take a Hike! During exploratory walks outside, students can look for both living and nonliving things.

Supporting Educational Research: *Benchmarks*, p. 103 (5A)
Related Science Standard: 1
Related Workplace Readiness Standards: 3.7, 4.2, 4.4

LEARNING ACTIVITIES: Grades 3-4

Are Raisins Alive? Students first pour several ounces of a clear carbonated drink in two clear plastic or glass cups. They drop a few raisins in one cup and a few frozen grapes in the other. The students then make observations regarding the "life" of these items. Are they giving off a gas? Are they moving on their own? Are they growing? What observations might convince the students that the raisins and grapes are living things? What evidence do the students find that indicates they aren't?

Scavenger Hunt! A simple scavenger hunt for feathers, leaves, bones, rocks, paper clips, etc., can enhance the living-versus-nonliving issue. After collecting the items, the students can then classify them.

Hay Infusion. Create a hay infusion in pond water. Within a few days, organisms will begin to appear at various levels. Students may need a microscope to see some of them. Many centuries ago, some people believed that living things occurred directly from dead things—a good topic for discussion.

Supporting Educational Research: *Benchmarks*, p. 341 (5A)
Related Science Standard: 1
Related Workplace Readiness Standards: 3.1, 3.2, 3.12

Indicator 2: Determine the basic needs of organisms.

LEARNING ACTIVITIES: Grades 3-4

Fish Watching. As students observe fish behavior, they make notes regarding the ways fish move, get food, defecate, and solve all their problems of living. As students study the behaviors associated with a fish, they can attempt to answer questions such as the following: Do fish drink? Do fish sleep? Do fish know their own young? Older students can map fish movements.

Critter Watching, continued. As an enhancement activity, each student can raise a small critter at his/her desk. Good candidates include mealworms, crickets, ladybugs, and butterflies. This activity sparks interest and permits students to closely observe animal behavior, which can later be compared with that of larger organisms such as mice or pets.

Ant Feeding. Students can determine which food ants prefer by finding an ant hill outdoors and placing a small spoonful of tuna, cat food, or meat scraps about one foot away from it. At a different location, students put honey, syrup, or fruit. Students then record their observations and discuss the preference they observe.

Mold Growing. Raising molds inside plastic bags allows students to closely examine their specimen yet avoids allergy problems. Students can list favorable conditions for mold growth and design experiments. They can assemble mold gardens and compare rates and duration of growth with soil vs. without soil, in cool vs. warm places, wet vs. dry places, and light vs. dark places. They should observe completed cycles and keep good records.

Egg Hatching. As an enhancement activity, the students can try to hatch eggs obtained from a private hatchery. Be sure homes are available for the hatchlings (required by law). Hatching brine shrimp in a classroom aquarium is another possibility.

Supporting Educational Research: *Benchmarks*, p. 116 (5D)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.9, 3.2, 3.7

Indicator 3: Show that living things have different levels of organization.

LEARNING ACTIVITY: Grades K-4

Ant Farm Cooperation. An ant farm can help students identify the division of labor that occurs with colonial animals. Supplementing with videos or laser discs will enable the students to see additional aspects that are not readily viewable.

LEARNING ACTIVITIES: Grades K-2

Beehive Business. Through role playing, children act out each of the different jobs performed by members of a beehive. Use fragrances to put scents only on certain members and not on others. Through their sense of smell, student bees try to figure out which bee is not from their hive. Students can perform a "bee dance" to help other bees find the flowers with the nectar.

More Role Play. Penguins, ladybugs, and ants are other possible animals that can be used for role play.

LEARNING ACTIVITIES: Grades 3-4

Social Organization, continued. Students compare and contrast the level of social organizations among people and other organizations.

Animal Homes. Students can investigate different biomes and animal habitats as well as the dwellings of animals that allow them to survive in their particular environments.

Embryonic Development. Starting with fertilized frog eggs, students discuss the changes in organization that occur as an egg develops. They then compare frog development with the development of other animals, including chicks and humans.

Supporting Educational Research: *Benchmarks*, pp. 111 (5C), 116 (5D)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.1, 3.2, 3.5, 3.7, 4.2, 4.7, 4.9, 5.6

Indicator 4: Show that plants and animals are composed of different parts serving different purposes and working together for the well-being of the organism.

LEARNING ACTIVITIES: Grades K-2

Aquatic Adaptations. How are fish adapted to life in the water? While studying fish in an aquarium, students figure out how each fin functions in the movement of the fish. They decide how the location and the structure of each fin contributes to its functions. Besides fins, how else is a fish adapted to life in the water? How does a fish eat? Does it drink the water? Videos, laser disc programs, guest speakers, and a trip to the library can supplement the classroom investigations.

Invent the Animal! Students create an animal or plant that can survive under a certain set of circumstances. An example would be: "What plant or animal could survive living in a mowed lawn?" Low-growing plants and burrowing animals would be best suited because they would not be injured by the mowing. Given pictures of butterflies or fish, students design backgrounds or shapes that allow the animal to be "hidden."

Create a Dinosaur! Show students a picture of a ferocious dinosaur. (Avoid T. Rex because it has recently been labeled a scavenger.) Students identify the parts of the body that were used for protection, movement, and feeding. Give students pictures of simple "bare-bones" dinosaurs and ask them to add pieces to the image that would add protection or aid in movement.

Supporting Educational Research: *Benchmarks*, p. 103 (5A)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.5, 3.2, 3.3

Indicator 5: Describe the life cycles of organisms.

LEARNING ACTIVITY: Grades K-2

Teddy Bears and Their Homes. There is a basic need among animals for a home. For some, a specific spot is a home, but for others, a big territory is required. This activity helps students examine the issues of a specific home and how it impacts their survival.

Students bring to class as many teddy bears as possible regardless of size. Supply the students with cardboard boxes (and lids) in a variety of sizes. Students can cut a small hole in the side of the small boxes and openings of different sizes on the larger boxes. The students then try to put their teddy bears into the boxes. Which teddy bears fit? How many can fit in a box? Which bears can enter more boxes than others? What happens to the bears that do not fit inside any of the homes? What happens when too many teddy bears get inside a single box? What happens if enemies get into a box with the bears?

Supporting Educational Research: *Benchmarks,* p. 119 (5E)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.2, 3.6, 5.6

LEARNING ACTIVITIES: Grades 3-4

Composting. After setting up a compost pile, students can study what animals grow in it, how fast they grow, and what happens to the material that the students originally placed in the pile. Older students can do population studies within this community.

Growing "Fast Plants." Obtain seeds of "fast plants" from a commercial biological supplier. (Fast plants are critical if the whole life cycle is to be observed.) Students can experiment to determine what conditions are best. Young students can discuss what they think plants need to grow and set up the activities that they are curious about. Older students can set up what they consider to be control experiments. The class can hold a contest to see who can grow the tallest plant.

Critter Watching. By raising mealworms, earthworms, or crickets, students can see a critter's entire life cycle. Older students can design experiments to study light-sensitivity behavior, color preferences, food preferences, and maze crawling. After recording results, students can share conclusions and discuss variables.

Supporting Educational Research: *Benchmarks,* pp. 119 (5E), 123 (5F)
Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 3.2, 3.4, 3.6

Indicator 6: Group organisms according to the function they serve in the food chain.

LEARNING ACTIVITIES: Grades K-2

Fly Away Home! The ladybug can serve as an excellent example of an insect filling a niche. Students discover how a ladybug scares away predators by observing them with a hand lens and conducting simple experiments with aphids and other plant pests. Students recognize how the ladybug fits into the food chain as they observe the foul secretion from its legs and the "after-dinner cleanup."

Outdoor Rot. Students can discuss decomposers and their role in various food chains. If possible, the students go for a walk outdoors looking for evidence of decomposition.

Indoor Rot. Take a clean container and make a mini-terrarium. Students can observe changes through its clear sides. Recording the changes on a regular basis will help the students determine what happens to the items they placed inside. The students can choose an assortment of items (e.g., food, leather, and paper) to place inside and keep moist.

Supporting Educational Research: *Benchmarks*, p. 123 (5F)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.1, 3.2, 3.6

LEARNING ACTIVITIES: Grades 3-4

Constructing Food Webs. With this activity, the class can simulate the relationships within a food chain. Each student picks an index card with the name of a plant or animal printed on it. The students toss differently colored balls of yarn to those students representing the organisms on which they can feed. Actual food chains and food webs become visible as the yarn balls get passed around from organism to organism. Students can discuss the roles of herbivores, carnivores, and omnivores. The number of links can be used to determine each organism's importance in the food chain. Students predict what will occur as organisms are randomly selected for extinction.

Observing Food Chains. Aquariums and terrariums provide excellent visual examples of the food chains within a community—as long as a variety of organisms is used. Encourage students to make regular observations and maintain a journal in which they record changes in diversity and the size of populations.

Supporting Educational Research: *Benchmarks*, p. 116 (5D)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.1, 3.2, 3.6

Indicator 7: Identify the major systems of the human body and explain how their functions are interrelated.

LEARNING ACTIVITIES: Grades K-4

Fasten Seat Belts! To prepare students for the study of the human body, read the book *The Magic School Bus Inside the Human Body*. Students trace an outline of their body on a large sheet of paper and indicate where the various parts are located inside. Using other paper, students cut out representative parts of each system and attach them to the appropriate location in their body outline. There are excellent videos and published activities to help students in their study of human anatomy and physiology.

The Nervous System. These few simple activities can demonstrate the functions of the human nervous system.

- Try testing students' hearing from different positions to see when the body detects the direction of sound best.
- What colors seem to cause the eye confusion? By examining optical illusions, students can see how the eye and brain must work together to interpret images.
- Students can determine their skin's sensitivity to touch by using toothpicks at varying distances of contact.

Eye-hand coordination can be tested by dropping a meterstick vertically from a low height and having students catch it as it falls. Students measure the point at which they catch the stick and compare the catch point over a number of trials. How is the nervous system, skeletal system, and muscle system working as a team? Why does reaction improve with trials?

LEARNING ACTIVITIES: Grades K-2

Smelling. Students try to identify the smells from certain unmarked bottles. Discuss the dangers of smelling unknown materials.

Hearing. Make a tape recording of common school sounds. Students identify each sound.

Touching. Students identify a variety of objects in a touch box.

LEARNING ACTIVITIES: Grades 3-4

The Circulatory System. Students discuss the heartbeat and how a pulse is created. They then take their own pulse at the neck (carotid pulse) by counting the number of beats in 15 seconds under various conditions (e.g., lying down, standing, and exercising). Will just wiggling their toes change the heart rate? What conditions or factors change the heart rate as measured by the pulse?

The Digestive System. This simple activity can demonstrate one of the functions of the human digestive system. The digestive system can be modeled by using a pair of old pantyhose. Students sew the waistband closed to form the stomach. They take one leg and cut off the toes to form a long piece of intestine. They create an esophagus by cutting the other leg so that just a six-inch (15-cm) piece remains attached to the panty. To simulate peristalsis, students place a wad of cotton in the esophagus and see the stretching and pushing that's necessary to get it into the stomach. Why is the stomach so wide compared to the rest of the tube? What happens in the stomach?

The Respiratory System. These two simple activities can demonstrate the functions of the human respiratory system.

- Students study the respiratory system by using a soda bottle filled with water, a piece of rubber tubing, and a masking-tape marker indicating specific volumes on the outside. They turn the filled soda bottle upside down in a washtub with the tube going up into the mouth of the bottle. The students exhale into the tube until they are out of air. They then measure the air on the side of the bottle to determine each student's lung capacity. Do all students have the same lung capacity? What factors can affect the volume?

- Students use a simple bell jar to demonstrate the roles that the rib cage and muscles play in the action of breathing. A balloon inside the bell jar will inflate and deflate as the rubber sheeting on the bottom is pulled down and released.

The Immune System. Students can use a simple simulation to study contagious diseases and the body's immune system. Fill a numbered cup with water for all but one student in the class. Fill the remaining cup halfway with water and the rest of the way with household ammonia. Give each student a new cup and ask them to take half the liquid from the matching numbered cup.

Students interact with peers by answering questions such as "Who would you like to have lunch with?" Then students go to that person and exchange some of the liquid from each other's cup. After about 12 questions, students add a drop of phenolphthalein to their cup. Many liquids will turn pink because they now contain some ammonia. Were they all "infected" with ammonia from the start? Now they add phenolphthalein or another suitable indicator (such as red cabbage juice) to the original cups to show that only one person was originally infected. That student infected all of the others by social contact. How could disease transmission been avoided? How is the body set up to prevent infections?

Supporting Educational Research: *Benchmarks*, pp. 136 (5C), 137 (5C)
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 3.2, 3.3, 3.5, 3.6, 3.12, 4.2, 5.1, 5.2, 5.9

Indicator 8: Describe and give examples of the major categories of living organisms and of the characteristics shared by organisms.

LEARNING ACTIVITIES: Grades 5-6

Field Trip! Students go on a field trip to a designated location. They collect as many living objects as they possibly can within the time frame of the trip. Collection methods include drawing, photographing, and/or videotaping. Upon returning to the classroom, students arrange their collections into areas labeled *PLANTS*, *ANIMALS*, and *UNKNOWN*. Students describe those items ending up in the *UNKNOWN* section, send information to other students via e-mail or the Internet, and/or ask a local high school biology class for help in identifying these unknowns.

Tree/Leaf Identification. By observing the patterns of veins in different leaves, students can use leaf pictures to identify trees. First, explain to students that because each type of tree produces its own distinctive type of leaf, studying leaves is one way scientists identify trees. Students discuss the three main vein patterns in leaves: *palmate, parallel,* and *pinnate.* After returning to the classroom, the students can choose from the following activities:

- Students create leaf rubbings by placing the leaf—vein side up—on a flat surface, covering it with a sheet of paper, and rubbing with the side of a crayon (making sure to hold the paper securely). They then compare their leaves, looking for similarities and differences among the various types of leaves. For help in identifying the types of trees from which the leaves were collected, students may use a tree guidebook or biological key.

- As a measurement activity, the students use graph paper for the rubbings and then measure each leaf's surface area.

- Students compose leaf pictures by arranging leaves under paper, muslin squares, or a T-shirt and then rubbing with a crayon.

Supporting Educational Research: *Benchmarks,* p. 342;
National Science Education Standards, pp. 14-15
Related Science Standards: 1, 2, 5
Related Workplace Readiness Standards: 2.7, 3.7-3.9, 5.6, 5.7

LEARNING ACTIVITIES: Grades 7-8

Classifying. Students categorize lists of plants and animals based on similarities and differences in structure. Concept maps can help students organize animals into vertebrates and invertebrates. Students then investigate major groups of vertebrates: fish, amphibians, reptiles, birds, and mammals. Students categorize common plants by the presence of flowers and the patterns of veins.

Animal and Plant Diversity. Students use a variety of sources to investigate the diversity of life.

- A visit to a pet shop provides living examples of most vertebrate groups.
- Plant diversity becomes apparent at any florist.
- Field trips to a zoo, the beach, or any New Jersey State Park can focus on the variety of life.
- The abundance of nature programs on the New Jersey Network and cable television channels offers an instant view of animal and plant diversity.

Plant and Animal Characteristics. As a class, students collect or list examples of living things that they encounter in their community. They then identify each example as *PLANT*, *ANIMAL*, or *OTHER*. After constructing a chart that compares the distinguishing characteristics of plants and animals, the students challenge each other's findings and debate the meaning of *plant* and *animal*. The characteristics shared by organisms include nutrition, reproduction, excretion, growth, and irritability. Students discover that some living things are neither plant nor animal.

Supporting Educational Research: *Benchmarks*, p. 341; Learning How to Learn
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 1.3, 3.8, 4.3, 4.10, 5.6, 5.9

Indicator 9: Recognize that complex multicellular organisms are interacting systems of cells, tissues, and organs.

LEARNING ACTIVITIES: Grades 5-6

System Components. Students make four large posters for each corner of the classroom and label them *CELLS*, *TISSUES*, *ORGANS*, and *SYSTEMS*.(Depending on the number of students in class, you can leave off *SYSTEMS* if you wish.) Students discuss the definitions of each. Each student takes a card with one of the following items written on it:

- *CELLS*—cardiac muscle, smooth muscle, skeletal muscle, nerve, stratified squamous epithelial, bone, fat, red blood cells, white blood cells
- *TISSUES*—muscle, nerve, epithelial, bone, fat, blood
- *ORGANS*—heart, stomach, brain, lungs, liver, bones, skin, blood vessels
- *SYSTEMS*—nervous, endocrine, reproductive, circulatory, muscular, skeletal, respiratory, digestive, urinary

Make sure that the cards are well scrambled. Ask students to go to the appropriate corner and tape their card on the poster. Students can discuss, ask questions, challenge each other, and assist each other.

Multimedia Investigations. Students incorporate a variety of technologies as they study the hierarchy of organization in living things. Using microscopes, students observe wet mounds of onion cells, cheek cells, *Elodea*, and pond-water organisms they have collected. Through both videodisc and Web browsing, students observe a variety of living things and determine where they fit in the hierarchy.

Supporting Educational Research: *Benchmarks*, p. 342; National Science Education Standards, p. 156
Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 2.7, 3.10, 4.5

LEARNING ACTIVITIES: Grades 7-8

Images of the Hierarchy. Using new or used catalogs from biological supply houses, students find and cut out pictures that represent each level of organization. They arrange these pictures to depict the relationship between cells, tissues, and organs. If prepared slides are available, students can compare their observations with the cells, tissues, and organs that they found in the catalogs.

Multimedia Investigations. Students incorporate a variety of technologies as they study the hierarchy of organization in living things. Using microscopes, students observe wet mounts of onion cells, cheek cells, and Elodea. Students draw what they see and write a paragraph that explains the hierarchy of organization in living things. Based on their analysis, students formulate definitions of cell, tissue, organ, and system. To supplement this activity, students use videodiscs to retrieve examples of cells, tissues built of these cells, and organs composed of the specific tissues.

Biosphere Components. As an extension of this hierarchy concept, students start at the atomic level to construct a visual illustrating their understanding of the organization of life. The following organization might be used: atom < molecule < cell < tissue < organ < system < organism < population < community < ecosystem < biosphere.

Supporting Educational Research: *Benchmarks,* p. 342;
National Science Education Standards, p. 156
Related Science Standards: 1, 2, 4
Related Workplace Readiness Standards: 2.7, 3.10, 4.5

Indicator 10: Identify and describe the structure and function of cell parts.

LEARNING ACTIVITY: Grades 5-6

Leaf Model. Although leaves come in a variety of shapes and sizes, all leaves perform the common function of photosynthesis. Students describe the cellular structure of a leaf by creating an edible model of a cross section of a leaf. Using a plastic shoe box as a mold, students disperse various foods in gelatin. Each piece of food represents a part of the leaf. The upper and lower epidermis is represented by green gelatin, and the mesophyll is represented by yellow gelatin. Stomata (banana pieces) and the palisade layer (grapes) are also included. Whipped cream represents the waxy cuticle.

Supporting Educational Research: *Benchmarks,* p. 342;
National Science Education Standards, p. 15
Related Science Standard: 2
Related Workplace Readiness Standard: 3.2

LEARNING ACTIVITIES: Grades 7-8

Analogies. These activities helps students construct their understanding of abstract microscopic structures such as the *nucleus*, *cell membrane*, *endoplasmic reticulum*, *mitochondria*, *cytoplasm*, *vacuole*, and *ribosome.*

- Students relate cell structure to familiar objects by comparing the cell to a factory. For example, the mitochondria is the energy generator for the cell factory, while the nucleus is the main computer that controls production. Students build a model of the factory, construct a chart, draw a diagram, and/or write an essay that expands the comparison and demonstrates their understanding.

- Alternatively, students can compare the parts of the cells to the human body. For example, the nucleus is the brain of the cell while the endoplasmic reticulum is the cell's circulatory system.

Time Line. As an extension activity, students construct a time line that traces the development of the cell theory from the first observations by Robert Hooke to our current understanding of cell structure.

Cell Model. Cell recipes are a fun way to investigate cell structure and function. Students can construct cell models using materials from the supermarket. They fill sandwich bags (cell membrane) with unflavored gelatin (cytoplasm). They then add the following ingredients to the "cytoplasm":

- cooked spaghetti (endoplasmic reticulum)

- rice (ribosomes)

- a hard-boiled egg (nucleus)

- celery slices (mitochondria)

- a small, water-filled balloon (vacuole)

After placing the "cell" in the refrigerator overnight to allow the gelatin to set, the students get a real feel for the cells by examining and dissecting their creation.

Supporting Educational Research:
Fulfilling the Promise—Biology Education in the Nation's Schools, pp. 18-19;
"Supermarket Cytology—Reinforcing Cell Concepts with Simple Models," pp. 22-25
Related Science Standards: 2, 3
Related Workplace Readiness Standards: 3.2, 5.2, 5.3

Indicator 11: Explain how organisms are affected by different components of an ecosystem and the flow of energy through it.

LEARNING ACTIVITIES: Grades 5-6

Ecosystem Research. In this research and writing activity, students use their knowledge of geography to locate biomes and ecosystems in different parts of the world. Using newspapers, magazines, and/or the Internet, students gather information about deserts, rain forests, or the tundra. After identifying the specific characteristics of each type of habitat, students attempt to determine the impact of humans on the environment. Students present their findings in the form of written reports, posters, or bulletin-board displays. Students can use the Internet to contact students in another biome to compare ecological features.

Ecosystem Simulations. Groups of students construct classroom terraria that represent a variety of ecosystems. Each group chooses a specific type of terrarium such as a desert, woodland, pond, or bog ecosystem. Plastic soda bottles can be easily adapted for this purpose. To construct a pond terrarium, students fill the bottom of a plastic bottle with aquarium gravel or sand, then add pond water, plants, water insects, guppies, and snails. The students research the kind of food needed by each animal. The students maintain accurate records of their observations as a long-term project. Students share information and investigate the effects of light and/or temperature on each terrarium.

Supporting Educational Research: National Science Education Standards, p. 158
Related Science Standards: 1, 2, 12
Related Workplace Readiness Standards: 2.2, 3.4, 4.2-4.9

LEARNING ACTIVITIES: Grades 7-8

Environmental Factors. Through a variety of indoor and outdoor activities, students can investigate the influence of living and nonliving factors on an ecosystem.

- By observing rye grass growing with bean seeds (indoors), students explore the interaction of populations.
- Using water samples that they bring to class, students determine the pH and/or test for the presence of nitrates.
- To determine how environmental factors influence growth, students design a controlled experiment that investigates the effects of light, temperature, moisture, soil type, and/or pH on the growth of radish seeds.

- Using an aquarium, students attempt to determine the effect of light, temperature, and pH on aquatic organisms.

- While outdoors, students collect and organize data on temperature, humidity, barometric pressure, rainfall, cloud cover, and wind direction. (If weather conditions are unfavorable, these data can be easily collected from the Weather Channel.) If students collect information throughout the school year, they can compute long-term averages and graphically display them.

Population Studies. As a field experience, students use sampling techniques to estimate plant populations. Students can easily compare population densities by using bar graphs.

Energy Flow. Using their population studies and investigations of nonliving factors, students attempt to predict the effects of adverse conditions on the flow of energy from producers to consumers. Students can use an energy pyramid to illustrate the relationship between amount of energy and the trophic levels.

Supporting Educational Research:
Fulfilling the Promise—Biology Education in the Nation's Schools, p. 24;
National Science Education Standards, p. 155.
Related Science Standards: 1, 2, 5, 12
Related Workplace Readiness Standards: 2.2, 3.12, 5.4, 5.11

Indicator 12: Illustrate and explain the life cycles of organisms.

LEARNING ACTIVITIES: Grades 5-6

Mealworm Life Cycle. Students use mealworms to investigate life cycles. Mealworms (beetle larvae) are easily maintained in the classroom and can be used to trace the development of an insect. Students record observations in a notebook or draw diagrams to show changes that occur. Students discover that a fertilized egg develops into a larva, which later changes into an adult form. Students compare the life cycle of the mealworm to that of other organisms.

Bird Life Cycle. Students construct their knowledge of life cycles by investigating familiar examples. The life cycle of birds provides insight into the stages of life. Students research the structure of a bird egg and trace the development of the embryo through its hatching. They recognize that young birds become adults and that adult birds take care of their young. Students diagram stages of chick embryonic development. They then compare the life cycle of birds to that of other familiar species like fish, frogs, and dogs.

Supporting Educational Research: National Science Education Standards, p. 157.
Related Science Standard: 2
Related Workplace Readiness Standards: 3.9, 4.2

LEARNING ACTIVITIES: Grades 7-8

Human Life Cycle. All of the events that occur between the beginning of one generation and the beginning of the next are part of the life cycle of an organism. Because the life cycles of plants and animals are continuous, students diagram these events as a circle. The human life cycle is an effective example of this biological concept. By comparing the life cycles of other living things to the life cycle of humans, students can gain an understanding of the variety of reproductive patterns.

Frog Life Cycle. To investigate the amphibian life cycle, students trace the development of a frog from egg to tadpole to adult. Eggs of *Rana pipiens* or *Xenopus laevis* are effective for this activity. Students keep a log of their observations and diagram the phases of development. If both types of eggs are available, students can compare the development and determine if development time varies with the species.

Butterfly Life Cycle. Raising butterflies is an exciting and inexpensive way to explore insect life cycles. The painted lady butterfly *(Vanessa cardui)* begins its life cycle as a small, pale-green egg. After several molts, the larva begins to pupate. The adult emerges after 7 to 10 days. For comparative purposes, students can collect crickets and maintain them in the classroom. The cricket *(Acheta domesticus)* demonstrates the nymph stage of the insect life cycle.

Plant Life Cycles. Students explore plant life cycles by germinating seeds. Students can plant corn and bean seeds in order to trace plant development. Alternatively, they can use Wisconsin Fast Plants™ *(Brassica rapa)*, which have a life cycle of 35 days. Shortly after students plant these seeds, seedlings emerge and develop. Students pollinate flowers and observe the formation of pods. Students compare the life cycles by drawing diagrams that include each stage of development.

Career Exploration. As an extension activity, students explore careers related to entomology and horticulture.

Supporting Educational Research: National Science Education Standards, p. 157.
Related Science Standard: 2
Related Workplace Readiness Standard: 1.3

Indicator 13: Identify and describe organisms that possess characteristics of living and nonliving things.

LEARNING ACTIVITIES: Grades 9-12

Respiration and Growth Investigations. This activity focuses on two life processes: *respiration* and *growth*.

- Students use bromothymol blue to detect the presence of carbon dioxide (a respiration by-product).
- They use germination and/or movement as growth indicators.

Students test these processes in "unknown" materials such as unlabeled radish seeds, bean seeds, lentils, packaged yeast, brine shrimp eggs, sawdust, sugar, salt, sand, and vermiculite. Students conduct the investigation in three segments:

- Using a microscope and hand lens, students observe the specimens and record their observations.
- They then test each material for carbon dioxide production.
- To determine growth characteristics, students place each unknown in a petri dish with a moist paper towel. They record their observations for at least four days.

Pond-Water Life. As an extension activity, students use microscopes to examine pond water. They try to distinguish between living and nonliving things in the sample. Students list the characteristics that are features of living systems. Point out that the characteristics universal to life are not always easy to observe. For example, a distinguishing feature of all life is the presence of cells or DNA.

Supporting Educational Research: *Benchmarks*, p. 341
Related Science Standard: 1
Related Workplace Readiness Standards: 2.2, 2.7, 3.9, 5.1, 5.4, 5.6

Viruses and Technology. Students examine electron micrographs of viruses. The students identify the characteristics of viruses that might indicate that they are living or nonliving. Using databases, students explore the impact of technology (e.g., electron microscopy or electrophoresis).

Viruses and Health. As a research and writing activity, students use databases to describe viruses that have a significant effect on world health. These viruses include Ebola and HIV/AIDS. Students describe modes of transmission and construct a global map depicting population distributions of infected individuals. As an extension of this learning experience, students view videos such as *The Band Played On* or *Common Threads*. These videos focus on the spread and identification of the origin of viruses. Students can obtain research information and epidemiological statistics from the Centers for Disease Control and Prevention (CDC) through the Internet.

Supporting Educational Research: *Benchmarks*, p. 341
Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 2.7, 3.12

Indicator 14: Identify and explain the structure and function.

LEARNING ACTIVITIES: Grades 9-12

Modeling Organic Nutrients. Students review the basic organic structures of carbohydrates, fats, and protein. In a cooperative learning experience, students design and construct models of three organic molecules that are found in living things: a simple sugar, a fat, and an amino acid. Students construct the molecular models from everyday materials such as paper clips, pipe cleaners, toothpicks, Styrofoam™ balls, colored tissue, aluminum foil, gumdrops, beads, seeds, or colored macaroni.

Testing for Organic Nutrients. For each type of organic nutrient, students describe its use in the cell, list examples, and explain its function. They then perform standard tests for the presence of each type of organic nutrient.

Testing Enzyme Activity. To demonstrate the variables that affect enzyme activity and substrate specificity, students run enzyme tests using potato or fresh calf liver. (Both contain the enzyme peroxidase.) Students determine the degree of enzyme activity by measuring the height of a foam column that is produced when the substrate (peroxide) is added. Students vary the pH, temperature, and amount of substrate to determine the optimum conditions for enzyme function. They then graphically represent their results. Students can use electronic probes connected to computers or calculators to make these measurements.

Supporting Educational Research: *Benchmarks*, p. 337;
Fulfilling the Promise—Biology Education in the Nation's Schools, p. 22
Related Science Standards: 2, 4, 5
Related Workplace Readiness Standards: 3.2, 4.2-4.9, 5.7

Indicator 15: Explain how plants convert light energy to chemical energy.

LEARNING ACTIVITIES: Grades 9-12

Investigating Photosynthesis. Students discover many of the basic facts of photosynthesis through laboratory experiences.

- Students determine if light is necessary for the production of starch (glucose). They loosely wrap some of the leaves of a *Geranium*, *Coleus*, or *bean plant* in foil and place the plant in bright light for several days. They pick the covered leaves and boil them first in water and then in alcohol. Next, they perform iodine tests for starch on the leaves. As a control, they conduct the same procedure on leaves that were not covered.

- Students investigate the effects of varying intensities of light on the amount of oxygen produced. They place aquatic *Elodea* plants in test tubes full of aquarium water and expose the test tubes to lamps placed at varying distances (5 cm outward). They cut the stems of the *Elodea* on a diagonal and place them in the test tubes upside down. Oxygen bubbles form on the cut end of the stems at a rate related to the distance from the lamp.

- Students determine if carbon dioxide is taken up by plants when the plants are exposed to light. First, students place a few drops of bromothymol blue (a carbon dioxide indicator) in a test tube partially filled with water. They exhale through a straw into the test tube until the color turns yellow. They then place an *Elodea* plant in the water in the test tube and expose it to light. (Bromothymol blue is not harmful to *Elodea*.) As the plant absorbs carbon dioxide, the yellow color changes back to blue.

- For extension, students design and carry out their own experiments to investigate how factors such as temperature or the concentration of carbon dioxide affect the rate of photosynthesis.

- The above experiments can be supported and extended through the use of computer lab interface devices or calculator probes to measure pH (carbon dioxide dissolved in water), light intensity, and temperature.

Supporting Educational Research: *Benchmarks*, p. 113
Related Science Standards: 2, 4
Related Workplace Readiness Standards: 2.7, 3.8, 3.12, 5.5, 5.8, 5.9

Indicator 16: Describe how plants produce substances high in energy content that become the primary source of energy for animal life.

LEARNING ACTIVITIES: Grades 9-12

Illustrating Plant/Animal Interdependence. The following activities illustrate the interdependence between plants and animals.

- Students set up, maintain, and observe a classroom aquarium or terrarium as an ongoing, small-scale example of the interdependence of living things and of the relationship between photosynthesis and respiration.

- As a challenge, students design and construct their own sealed terrarium, in which the only thing entering the system from the outside is sunlight.

Students use print and/or Internet resources to research the Biosphere project in Oracle, Arizona, to determine how it was set up, what problems were encountered, and how those problems are being addressed.

Supporting Educational Research: *Benchmarks*, pp. 118-21
Related Science Standards: 1, 2
Related Workplace Readiness Standards: 2.6, 3.7, 4.2-4.9

Investigating the Photosynthesis/Respiration Connection. The following activities enable students to investigate the relationship between photosynthesis and respiration.

- To illustrate the interdependence of plant and animal life, students take a small sample of water from a healthy classroom aquarium and test it with a few drops of bromothymol blue for the presence of carbon dioxide (carbonic acid). They fill a beaker with water from the aquarium and place a goldfish in the beaker. Students periodically remove a few milliliters of water from the beaker and retest for carbon dioxide. When the water in the beaker tests positively for carbon dioxide, students return the goldfish to the aquarium. They then place a few aquatic plants such as *Elodea* into the water in the beaker, add a few drops of bromothymol blue, and place the beaker in bright light for a day or two.

- As an extension, students use print and/or Internet resources to investigate the historical contributions of the British chemist, Joseph Priestley.

Supporting Educational Research: *Benchmarks*, pp. 82, 118-21
Related Science Standard: 3
Related Workplace Readiness Standards: 2.6, 3.9, 5.4

Indicator 17: Compare and contrast the life cycles of living things as they interact with ecosystems.

LEARNING ACTIVITIES: Grades 9-12

Effect of Environmental Factors on Germinating Seeds. In the following activities, students investigate the response of the roots and stems of germinating corn or bean seeds to such environmental factors as gravity, light, and water.

- To investigate the response of germinating roots and stems to gravity, students place four soaked corn or bean seeds on barely moist paper towels that are pressed into a petri dish. The seeds should be at the 3 o'clock, 6 o'clock, 9 o'clock, and 12 o'clock positions. The students then stand the petri dish on edge in a fixed position and check daily for the direction of growth of the emerging root and shoot.

- As an extension, students work in cooperative lab groups to design their own experiments testing the responses of germinating seeds to the direction of a light source or a water source. Students focus not only on the design of their experiments but also on writing detailed procedures. (They will swap experimental designs and procedures with another group before carrying out the experiment.)

Supporting Educational Research: *Benchmarks,* pp. 118-21
Related Science Standard: 2
Related Workplace Readiness Standards: 3.6-3.12, 4.2-4.9

Fallen Leaves and Invertebrate Populations. The following activities enable students to study the interaction of living things in an ecosystem.

- Using ordinary plastic net bags (e.g., onion, orange, or grapefruit) filled with leaves, students investigate how the life cycle of a deciduous tree impacts the life cycles of invertebrates. Students fill the net bags with 50 leaves of varied types and dryness. In mid-October, the bags are secured to rocks in a stream bed or tied to trees and placed where natural leaf packs form. After three weeks, students return to recover their net bags. (Bags that were in stream water should be placed in containers filled with stream water.) Students note the diversity of life forms on the leaves.

- As an extension, students explore the work of limnologists, EPA officials in the field, and insect control agencies.

Supporting Educational Research: *Benchmarks,* p. 121;
Fulfilling the Promise, p. 21
Related Science Standards: 2, 12
Related Workplace Readiness Standards: 1, 3.9, 4.2-4.10